

BELLCOMM. INC.

955 L'ENFANT PLAZA NORTH, S.W.

WASHINGTON, D. C. 20024

B70 04024

SUBJECT: Revision of Operational Constraints
for J Mission Traverse Planning -
Case 320

DATE: April 7, 1970

FROM: P. Benjamin

ABSTRACT

A framework for the construction of lunar surface traverses is created, consistent with the requirements and constraints of the J missions. The framework presented represents a revision of a previous memorandum on the subject and reflects recent assumptions of capability and the results of Apollo 11 and Apollo 12 experience altered for J mission requirements and constraints with optimistic projections for increased technological capability and confidence. A 66 hour lunar surface stay provides time for one 6 hour and two 7 hour EVA's as well as three 8 hour rest periods.

All non-traverse activities required for each EVA are identified and the time available for the traverse is determined. On EVA 1, the traverse is 1 hour and 5 minutes long; 5 hours and 35 minutes are available for the traverse in EVA 2; and the EVA 3 traverse has a length of 5 hours and 22 minutes. Using the agreed upon program assumptions for riding and science activity metabolic rates, nomographs for the calculation of traverse distance versus science time available are presented. Time limits constrain the EVA 1 traverse, while time and consumables constraints are evenly matched for the traverse in EVA 2. Consumables limit the third traverse.

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MEMORANDUM FOR FILE

INTRODUCTION

In order to perform J mission traverse planning, it is necessary to determine the context and constraints which define the character of each EVA. A previous memorandum (ref. 1) considered the scheduling of 3 EVA's within a 54 hour lunar surface timeline, the determination of the time available in each EVA for the geologic traverse, and the calculation of the resulting time and consumables constraints. Changes in ground rules and hardware utilization techniques have modified these constraints. This memorandum indicates the new form of these constraints in order to provide a current context within which traverses may be designed.

LUNAR SURFACE STAY TIMELINE

Present indications point to a LM lunar surface stay time of 66 hours for the J Missions. Figure 1 shows a probable form of the timeline as adapted from data presented at the February 24 Mission Review (ref. 2). Three 8 hour rest periods divide the surface stay into 4 days. The first day includes touchdown and a 6 hour EVA. The second and third days have one 7 hour EVA each. Lift-off occurs 3 hours into the last day, providing the maximum opportunity to begin orbital science tasks on that day. The first EVA is restricted to a 6 hour length because it falls at the end of an extremely long day--23 hours between rest periods. The next two days have about 13 hours awake, and the length of the final day is determined by orbital science.

EVA TIMELINES

The 3 EVA's as presented here are planned to consume the full time allotted to them. The times proposed for the activities shown represent the results of Apollo 11 and 12 experience modified by the requirements for J mission activities. A conscious attempt has been made to choose the most optimistic estimate of task times and to assume

that extensive prior experience in lunar surface operations will have led to carefully coordinated and scheduled timelines with optimum crew interaction. All timelines are from depress to repress, and the time available for the traverse is that remaining after all other required activities have been provided for. As is shown below, this time is different for each EVA.

The first EVA, as shown in the timeline of Figure 2, is almost entirely devoted to operational tasks and ALSEP deployment. Only 1 hour and 5 minutes remain for an LRV traverse. The first 1 1/2 hours of the EVA are devoted to inspection and operational tasks at the LM common to all missions except that the LRV deployment mechanism is activated during LMP egress. If TV monitoring of LRV deployment is desired, the TV deployment can precede LMP egress. Switch-over to the erectable antenna is a function of 210 ft dish coverage and LM power profiles. Elimination of the switch-over requirement or relocation of the switch to the outside of the descent stage could add as much as 15 minutes to the traverse. Two hours are devoted to ALSEP related tasks, this portion of the timeline approximating that of Apollo 13. The estimates of LRV related tasks precede any firm knowledge of the exact activities and equipment involved or the amount of time required. It would seem unlikely, though, that the times required will be much lower than those shown in Figure 2. Only a minimal time is provided at the end of the EVA for the final operational tasks and ingress.

The second EVA, shown in Figure 3, provides the longest traverse time, 5 hours and 35 minutes. Minimal activities precede LRV preparation, and the traverse begins prior to the second hour of the EVA. Just over 1/2 hour of post-traverse activities is required to conclude the EVA, as in EVA 1.

The pre-traverse activities of EVA 3, shown in Figure 4, require slightly less time than EVA 2 because transfer of consumables for a continued surface stay is not required. Traverse time is slightly reduced to 5 hours and 22 minutes, however, due to increased requirements for post-traverse activities. The three EVA's are summarized in Figure 5. A total of 40 man hours of EVA are available, of which 24 man hours may be used for traverses.

CONSUMABLES AND TIME CONSTRAINTS

Consistent with values agreed upon (ref. 3) and accepted by the program, an average metabolic rate of 1100 Btu/hr is assumed for all activities except riding the LRV, which is assumed to be 700 Btu/hr. For walkback from a disabled LRV, a

metabolic rate of 1200 Btu/hr is assumed to correspond to a 4 km/hr lope. In case of PLSS failure, the Buddy SLSS is assumed to provide a 10 km return capability on the LRV. Double failures--both the PLSS and the LRV--are not considered.

Extension of the EVA's to 7 hours was permitted by the inclusion of a 7.3 hr battery in the -7 PLSS. The A7LB suit should provide additional comfort over the A7L, and the installation of a drinking water supply in the suit has alleviated concerns over possible dehydration during extended EVA's. The -7 PLSS has a total cooling capacity of 10,200 Btu of which some fraction is available for metabolic cooling. Based upon -6 PLSS experience, MSC has been evaluating this capability and has generated the consumables curves shown in Figure 6 (ref. 2). These show that for no heat inleak and no O₂ leak, a metabolic capacity of at least 7000 Btu may exist over the range of metabolic rates of interest here. The capacity of the PLSS for metabolic rate related consumables is assumed to vary as a function of increasing sun angle and decreasing recharge capability over the duration of the lunar surface stay. Consequently, the values 6750 Btu, 6500 Btu and 6250 Btu have been adopted as the metabolic capacity for the 3 EVA's, respectively. It is further assumed that the LRV will be available for all traverses.

Figures 7, 8, and 9 are nomographs for use in the calculation of traverse distance versus science time for the 3 EVA's. An explanation of the structure and use of these nomographs has been published (ref. 4). Each chart shows the traverse time limit developed above for that EVA as well as the PLSS consumables limit after provision for non-traverse activities. It appears from these charts that on EVA 1 (only 6 hours), the time constraint will limit the traverse length. On EVA 2, time and consumables limits are evenly matched, and on EVA 3, consumables are the limiting factor.

SUMMARY AND CONCLUSION

A 66 hour lunar surface stay can accommodate one 6 hour and two 7 hour EVA's as well as three 8 hour rest periods. This results in a long TD day, including the short EVA, followed by two short days with 7 hour EVA's. LO occurs early enough in the final surface day to provide time to begin lunar orbital science.

LRV and ALSEP deployment activities limit the LRV traverse in the first EVA to only 1 hour and 5 minutes. The EVA 2 traverse is 5 hours and 35 minutes in length, and 5 hours and 22 minutes are available for the traverse in EVA 3. The short time constraint on EVA 1 proves to be the limiting factor on the traverse in this EVA, while the time and consumables limits are matched for the EVA 2 traverse. Consumables are limiting in the EVA 3 traverse.

The information developed here has been created to form a framework for the construction of lunar surface traverses consistent with the requirements and constraints of the J missions. Necessarily, at this stage in the development of the program, a number of assumptions have been required to produce this framework. An attempt has been made to list these assumptions and their rationale. The assumptions made parallel those of the previous memorandum on this subject and are modified over those previously made to reflect the best information currently available with optimistic projections for increases in technological capability and confidence. Any traverses based on this framework will be realistic to the extent that these assumptions are reasonable, and suggestions for modifications are welcomed by the author.



P. Benjamin

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Attachments
Figures 1-9

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References

1. P. Benjamin, "Operational Constraints for J Mission Traverse Planning," Bellcomm Memorandum for File B70 01012, January 7, 1970.
2. J. Sevier and R. Ward, "J Mission Lunar Surface Timeline Considerations," ASPO Presentation to Mission Review, MSC, February 24, 1970.
3. T. A. Bottomley, "Definition of Energy Costs for Lunar Surface EVA," Bellcomm Memorandum for File B69 09027, September 8, 1969.
4. P. Benjamin, "Handy Dandy Charts for Determining Operational Constraint Effects in Lunar Traverse Planning," Bellcomm Memorandum for File B69 10042, October 15, 1969.

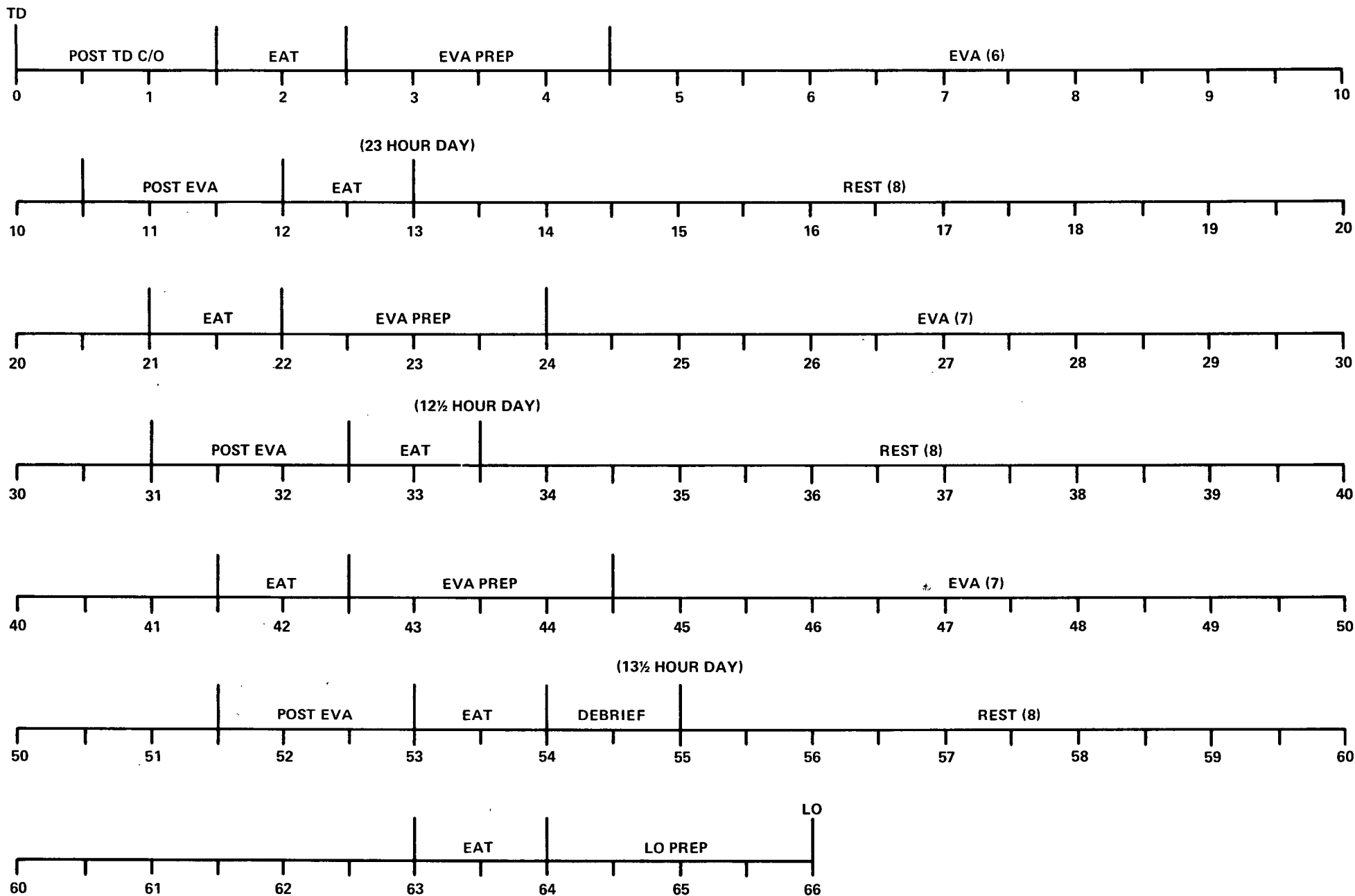


FIGURE 1 —LUNAR SURFACE TIMELINE

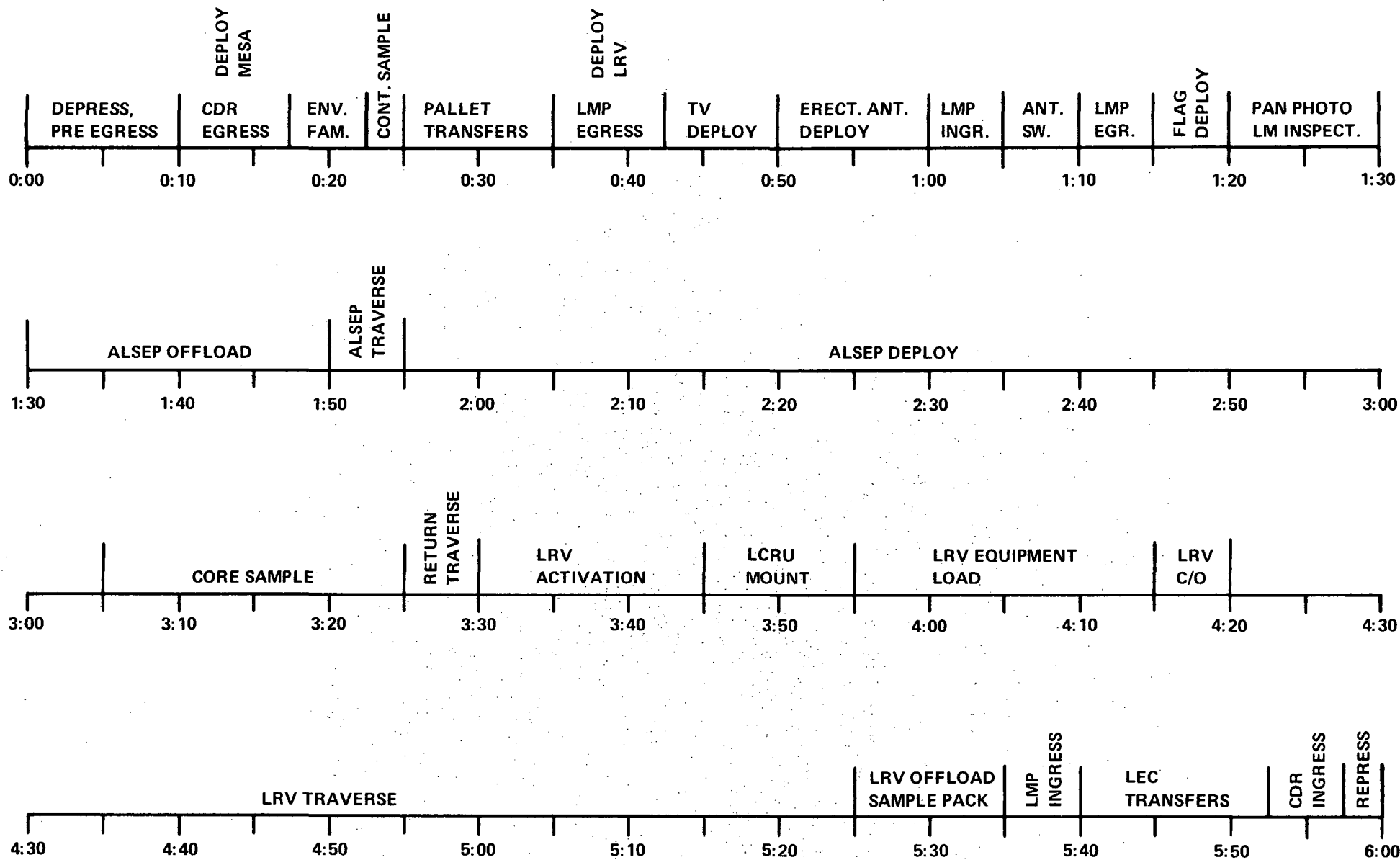


FIGURE 2 —EVA 1 TIMELINE

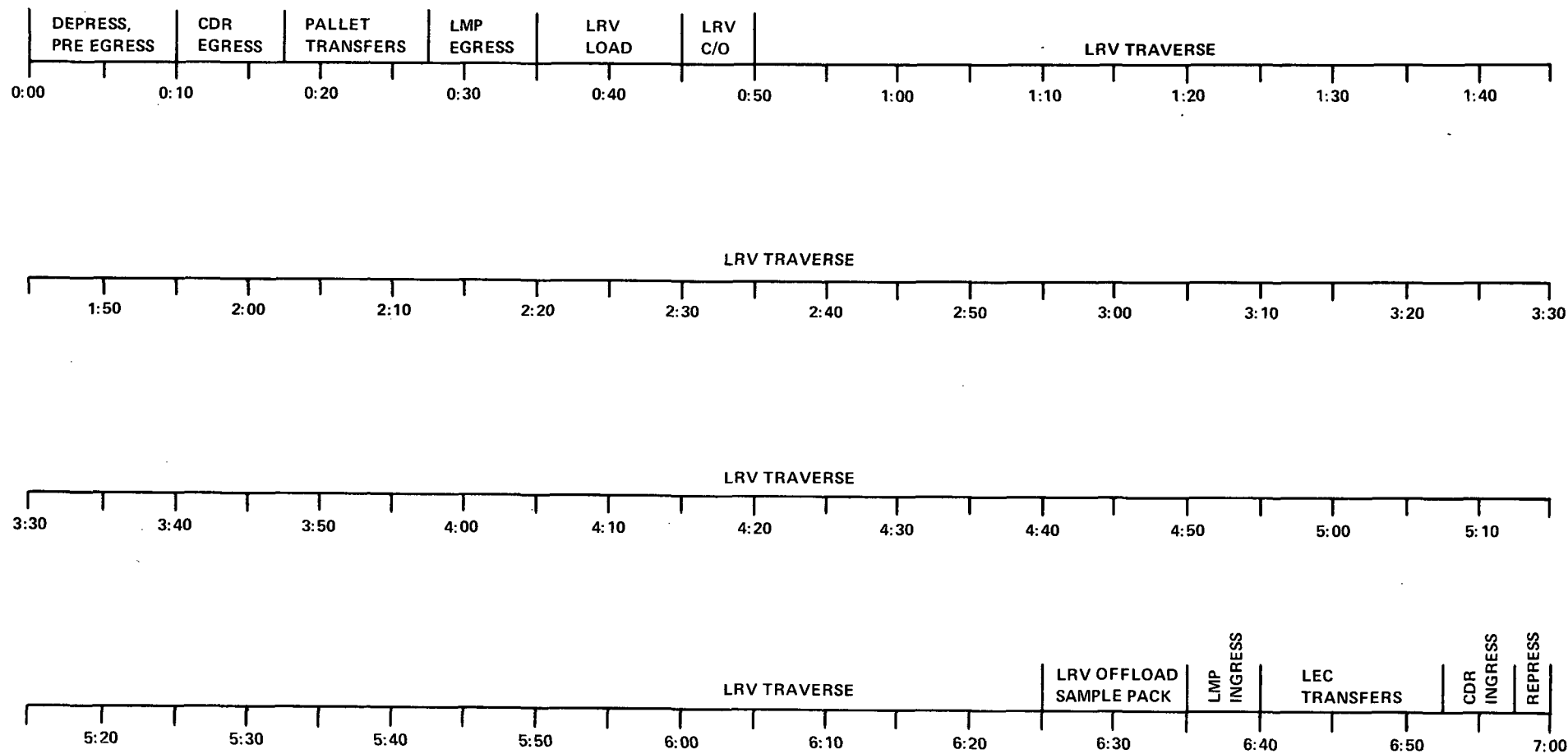


FIGURE 3—EVA 2 TIMELINE

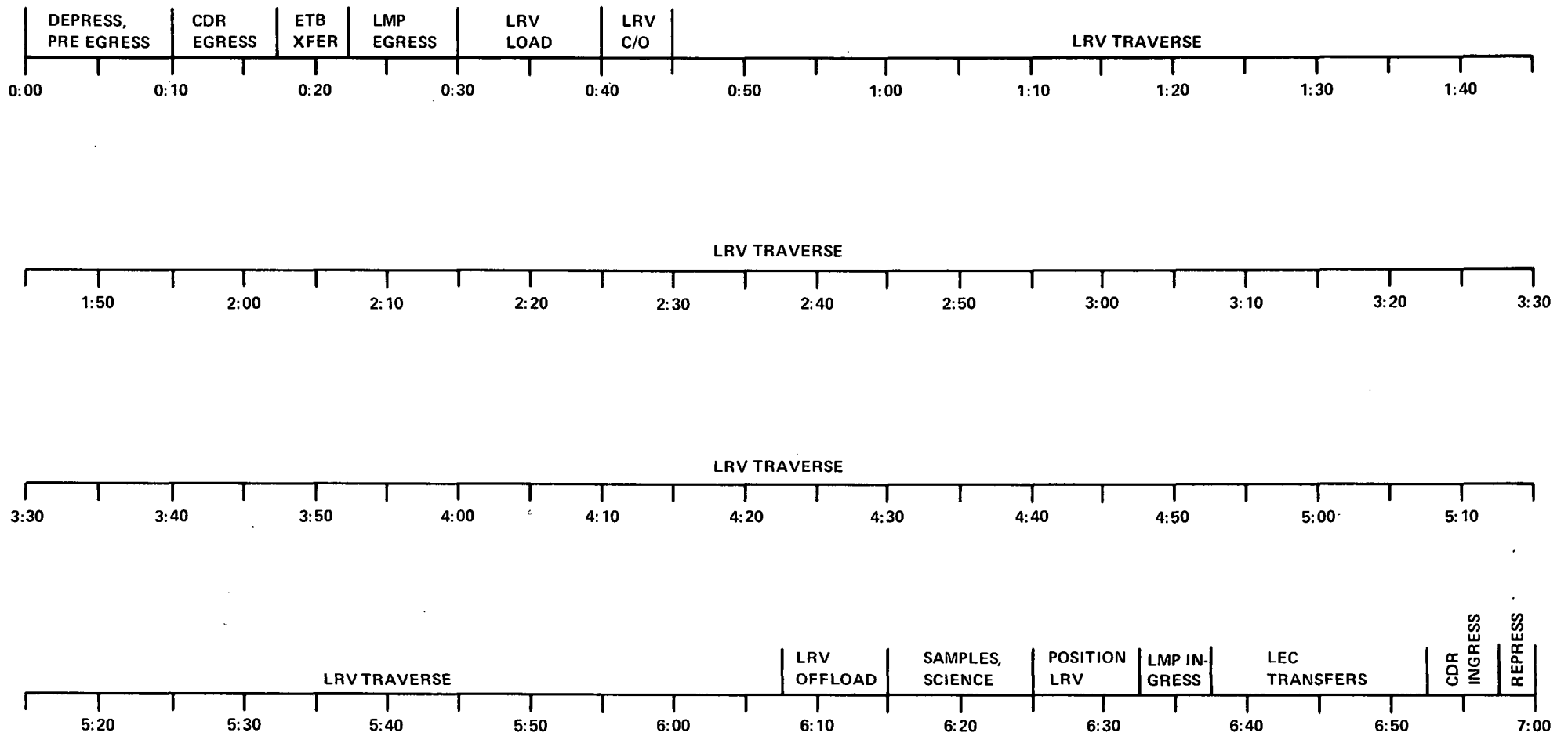


FIGURE 4 —EVA 3 TIMELINE

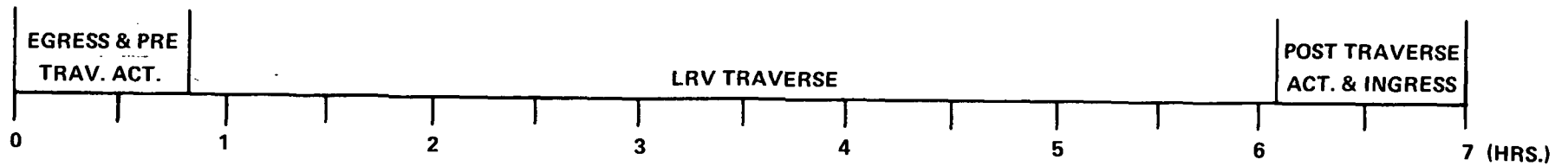
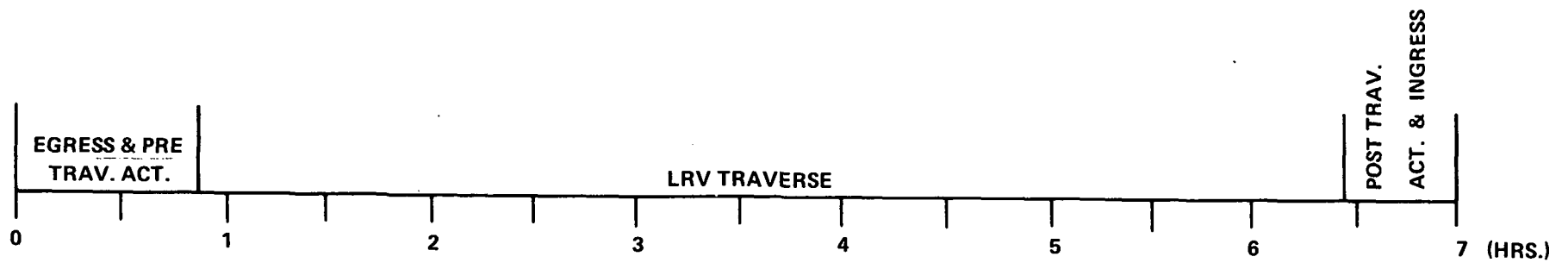
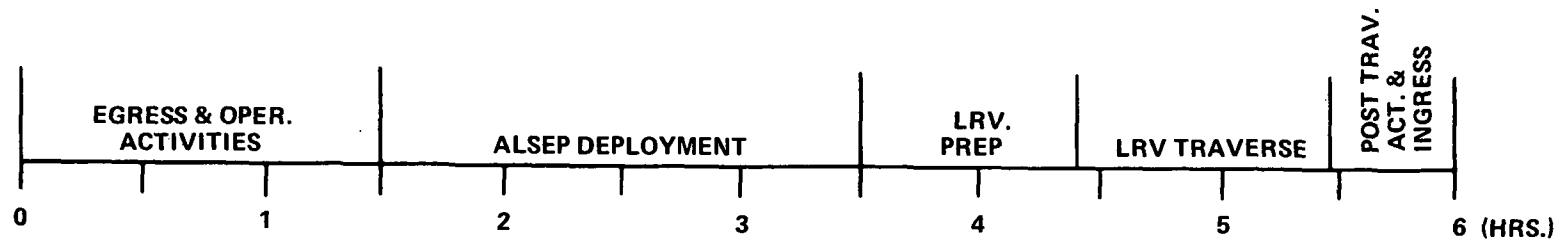
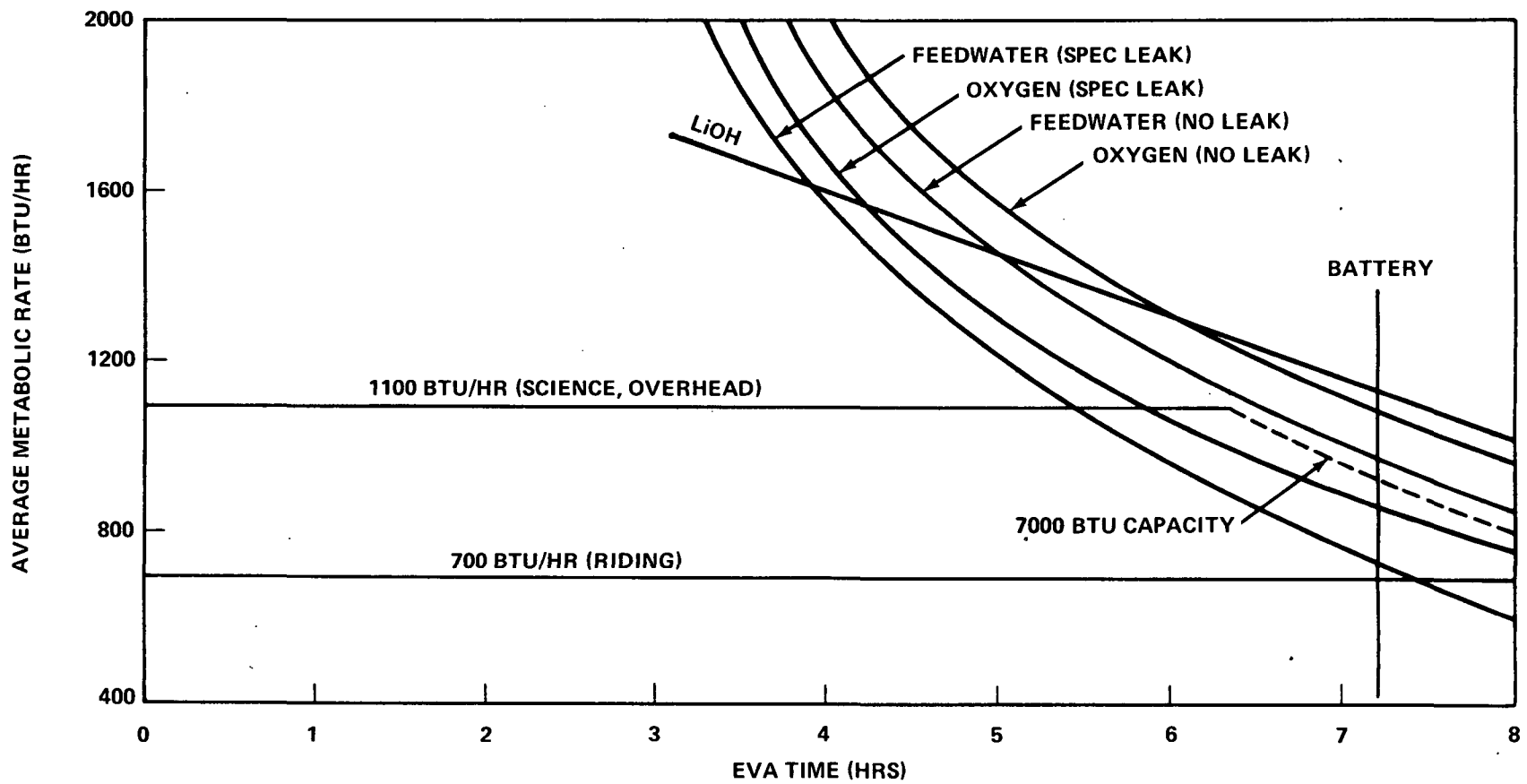


FIGURE 5 - EVA SUMMARY



FROM MSC DATA

FIGURE 6: - 7 PLSS CONSUMABLES

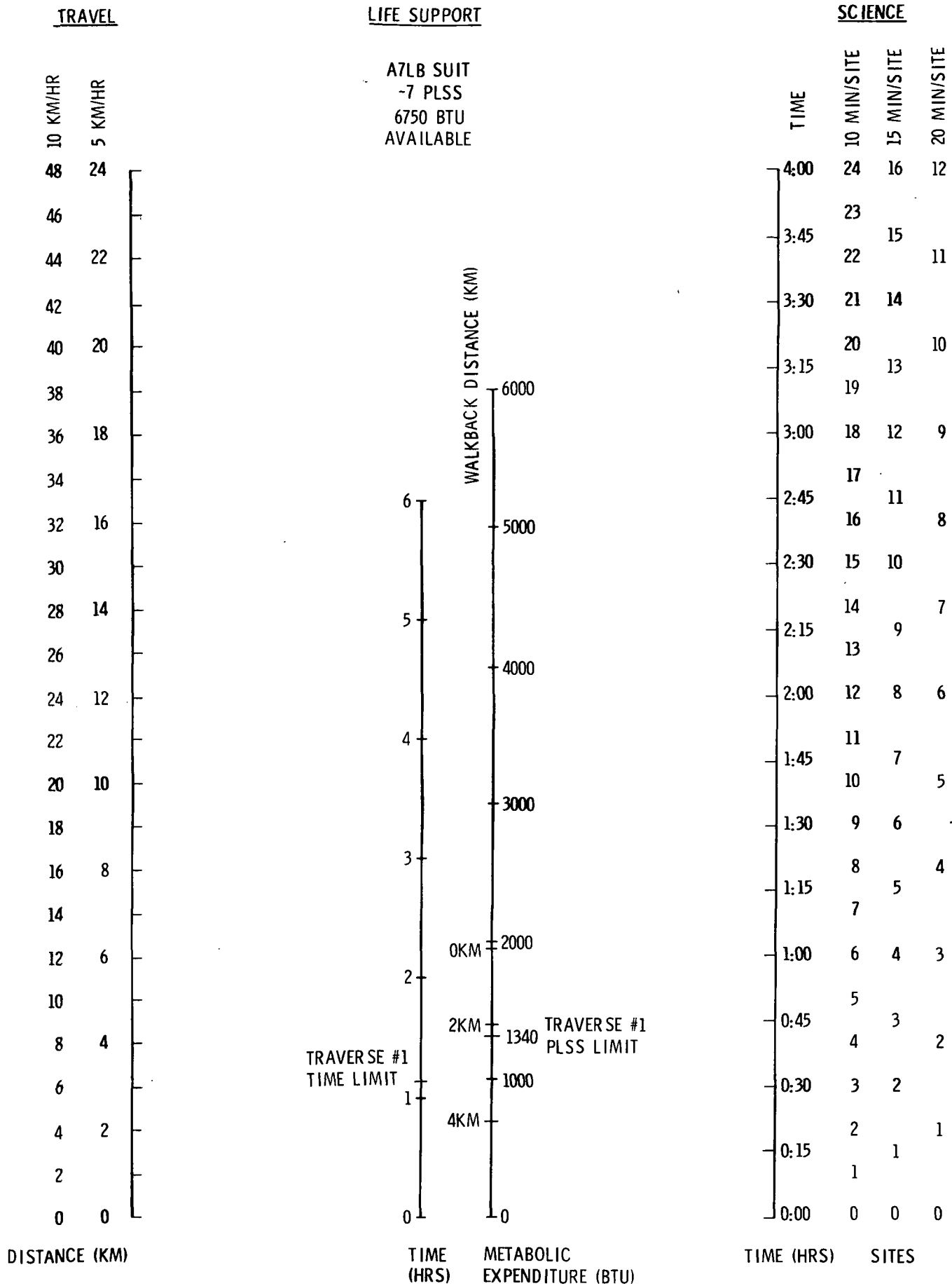


FIGURE 7 - TRAVERSE #1 PLANNING CHART

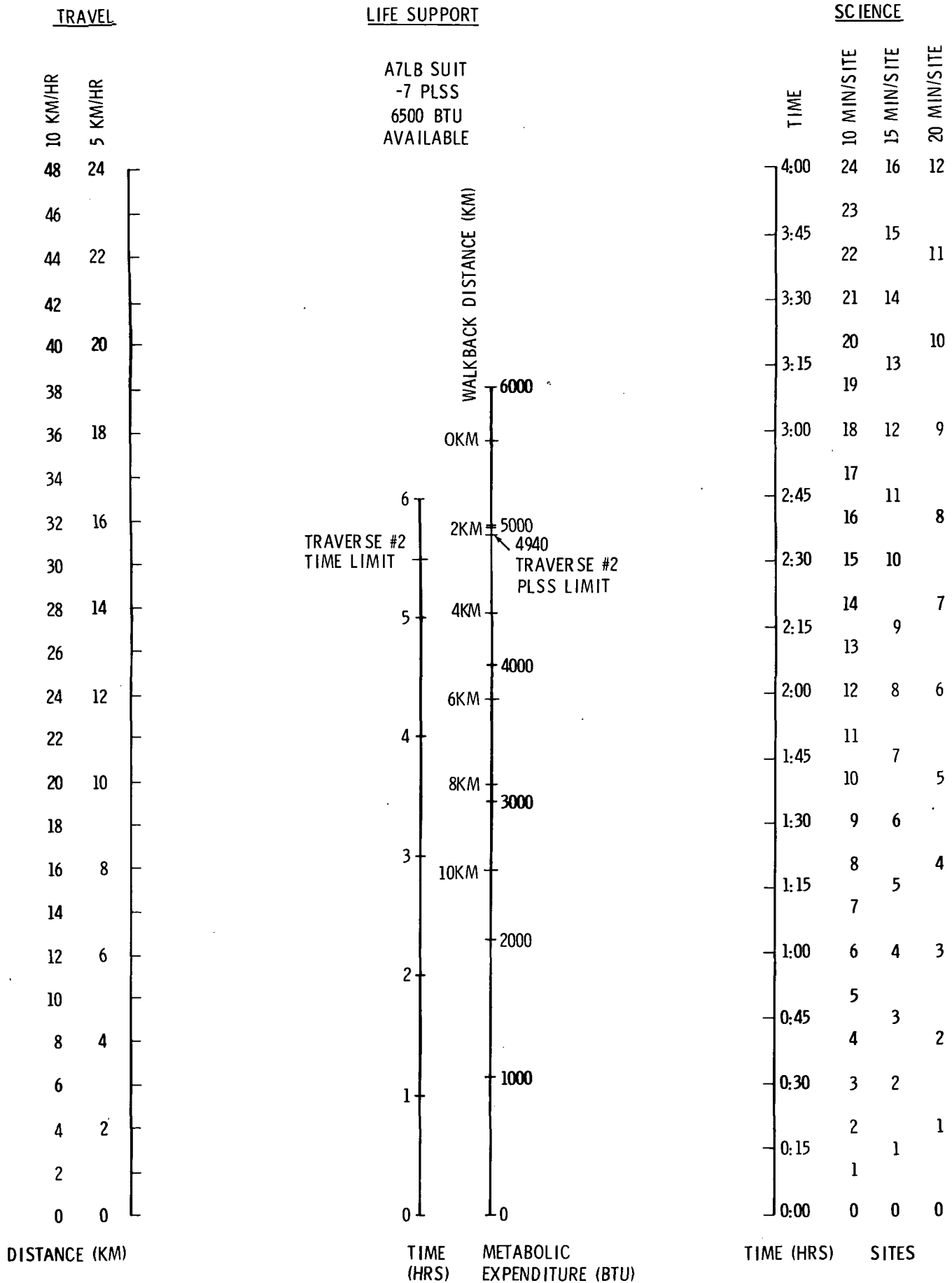


FIGURE 8 - TRAVERSE #2 PLANNING CHART

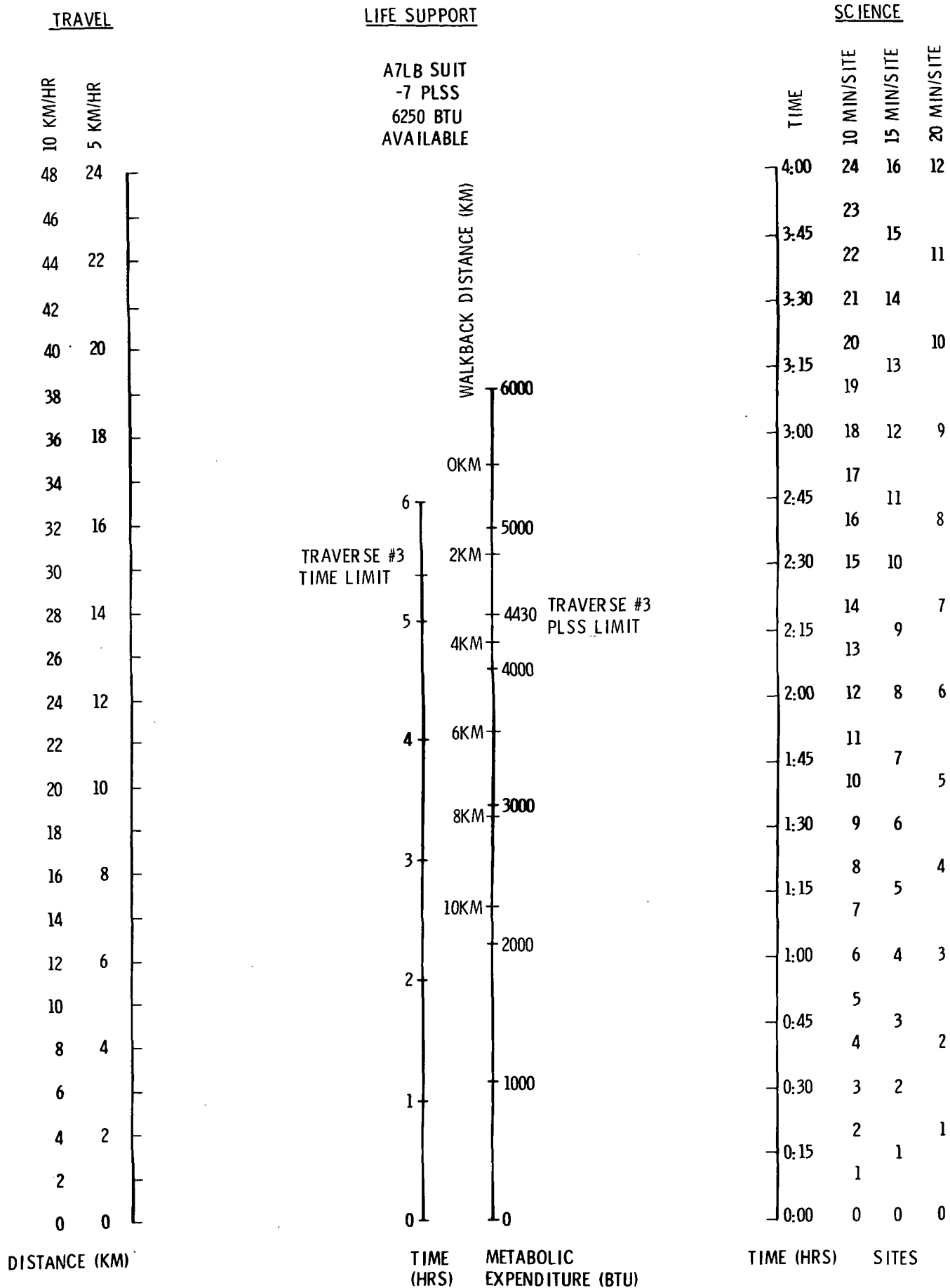


FIGURE 9 - TRAVERSE #3 PLANNING CHART

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